Check List the journal of biodiversity data

NOTES ON GEOGRAPHIC DISTRIBUTION

Check List 19 (5): 611–620
https://doi.org/10.15560/19.5.611

PENSOFT

New record of *Azurina intercrusma* (Evermann & Radcliffe, 1917) (Ovalentaria *incertae sedis*, Pomacentridae) and confirmation of *Scuticaria tigrina* (Lesson, 1828) (Anguilliformes, Muraenidae) in the Galápagos Islands

William Bensted-Smith[1*], Inti Keith[1], Jack Grove[2], Stuart Banks[1]

1 Charles Darwin Research Station, Charles Darwin Foundation, Santa Cruz, Galápagos, Ecuador • WBS: billy.benstedsmith@fcdarwin.org.ec https://orcid.org/0009-0001-6848-7594 • IK: inti.keith@fcdarwin.org.ec https://orcid.org/0000-0001-9313-833X • SB: stuart.banks@fcdarwin.org.ec https://orcid.org/0009-0007-5015-0903

2 East Pacific Corridor Alliance, Tavernier, FL, USA • JG: jgrove@epcafoundation.org https://orcid.org/0000-0002-7110-2931

* Corresponding author

Abstract. Herein we provide the first published records for *Azurina intercrusma* and a correction of previous *Scuticaria tigrina* records within the Galápagos Marine Reserve. The former had not previously been reported north of the southern Ecuadorian coastline and represents a significant step outside of its known distribution for this cold-water species. *Scuticaria tigrina* had been mentioned in previous literature as present, but its inclusion appears to have been in error; we confirm its presence as a vagrant and provide evidence of live observations in different parts of the archipelago.

Keywords. Citizen science, Eastern Tropical Pacific, new record, reef-eel, reef-fish, scuba diving, subtidal monitoring

Academic editor: Arturo Angulo
Received 6 June 2023, accepted 23 August 2023, published 18 September 2023

Bensted-Smith W, Keith I, Grove J, Banks S (2023) New record of *Azurina intercrusma* (Evermann & Radcliffe, 1917) (Ovalentaria *incertae sedis*, Pomacentridae) and confirmation of *Scuticaria tigrina* (Lesson, 1828) (Anguilliformes, Muraenidae) in the Galápagos Islands. Check List 19 (5): 611–620. https://doi.org/10.15560/19.5.611

Introduction

The Galápagos are famous for their abundant native and endemic marine wildlife (Bustamante et al. 2000) and the dangers of introduction of non-native species through anthropogenic vectors (Keith et al. 2016; Carlton et al. 2019); however, what is less well-documented is the flux of "vagrant" marine species through the islands' waters (McCosker and Rosenblatt 2010). Much of the ocean's fauna and flora have a pelagic larval stage during their development (Orton 1953; Strathmann 1993) and this, combined with the oceanic currents interacting with the Eastern Tropical Pacific (ETP) (Kessler 2006), occasionally leads to rare or previously unseen species appearing in the archipelago. These "vagrant" species are usually unable to establish populations and are just temporary residents on the islands, such as the butterflyfish of the Indo-Pacific which can be observed sporadically along the reefs of Darwin and Wolf (Fig. 1) (Robertson and Allen 2015). However, occasionally sufficient individuals of a given species arrive, find each other, and establish a long-lasting breeding population, the likelihood of which is also dependent on the adaptability of the species to the seasonally changing habitats in the Galápagos (Houvenaghel 1984; Kessler 2006).

Azurina D.S. Jordan & McGregor in Jordan & Evermann, 1898, belonging to the subfamily Chrominae, is a genus which has undergone several taxonomic revisions over the past decade and a half. Originally containing only two species, it was considered endemic to the ETP (Robertson and Allen 2015) and comprised of

©The authors. This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

damselfish with a continuous lateral line and deeply forked caudal fin (Jordan and Evermann 1896; Heller and Snodgrass 1903). This classification has since been superseded by Tang et al. (2021), who assigned 10 species to the genus *Azurina*, among those, and for the first time, *A. intercrusma* (Evermann & Radcliffe, 1917). This expanded genus now incorporates all species previously assigned to *Chromis* G. Cuvier, 1814 with XII dorsal-fin spines from the Atlantic and Eastern Pacific, as well as two Indo-West Pacific species with the same morphological characteristics. Only two species within the clade differ from this definition, including the possibly now extinct Galápagos endemic (Edgar et al. 2010; McCosker and Rosenblatt 2010; Russell and Craig 2013) *A. eupalama* Heller & Snodgrass, 1903 (with XII–XIV dorsal-fin spines; Heller and Snodgrass 1903). *Azurina intercrusma* is one of the species assigned to *Azurina* but not examined within the study by Tang et al. (2021) due to it also possessing XII dorsal-fin spines and having an Eastern Pacific distribution (Robertson and Allen 2015), traits which are shared by only two species in the subfamily Chrominae, all of which have been classified as *Azurina*. This identifier, in conjunction with several other morphological features, led the authors to assign *Chromis intercrusma* to *Azurina sensu lato* (Tang et al. 2021).

Prior to the present study, the Galápagos Islands were known to house only one extant species of *Azurina* (*A. atrilobata* (T.N. Gill, 1862)), or two if the aforementioned *A. eupalama* is considered. There have been no records of *A. intercrusma* in the Galápagos Marine Reserve (GMR) in any of the principal global fish location aggregator databases (FishNet 2 2023; iNaturalist 2023; GBIF 2023; OBIS 2023). In fact, the northernmost record was in 2021 during an intertidal biodiversity monitoring (Martínez Panizo et al. 2022) of the Bajo Copé Marine Reserve (Ministerio del Ambiente 2020) off the coast of Ecuador at a latitude of 01.8°S, with its

Figure 1. Map of the Galápagos Islands showing the locations at which *Azurina intercrusma* (**A**) and *Scuticaria tigrina* (**B**–**D**) were observed. Map created by Emily McFarling and Johny Mazón (CDF).

normal range extending from the southern coast of Ecuador south to Chile between depths of 0 and 35 m (Robertson and Allen 2015).

On 7 April 2022, W. Bensted-Smith observed a single juvenile of *A. intercrusma*, ~7 cm long, swimming amongst the rocks (Fig. 2A, B) at a depth of 6 m during a Subtidal Ecological Monitoring (Banks 2014) scuba dive at the tourist site of Punta Moreno on the southwest coast of Isabela Island (Fig. 1A). It was noted that this individual was swimming alongside a similar-looking *A. atrilobata*, and it could be differentiated from this species due to the lack of a prominent white spot just below the end of the base of the soft dorsal fin, which is characteristic of *A. atrilobata* (Fig. 2C). No other individuals were noted at any of the other 52 dive sites along the coastlines of western Isabela or the neighbouring island of Fernandina during that monitoring effort.

The morays of the world (Muraenidae) are divided into two subfamilies, Muraeninae and Uropterygiinae, the latter of which contains five genera (Loh et al. 2008). All five can be found within Pacific waters, but only *Anarchias*, *Uropterygius*, and *Scuticaria* are present in the ETP (GBIF 2023; OBIS 2023). The genus *Scuticaria* Jordan & Snyder, 1901, originally a subgenus of *Uropterygius* Rüppell, 1838, was only recognised as its own genus in 1997 (Böhlke and McCosker 1997) and includes just two species, *S. tigrina* (Lesson, 1828) and *S. okinawae* (Jordan & Snyder, 1901). *Scuticaria tigrina* is a widely distributed species, spanning the Indo-Pacific, and yet relatively little is known about its population trends, ecology, and natural history due to its nocturnal nature. In fact, no *S. tigrina* leptocephali were identified until 2012, when a genetic and morphometric analysis of several collected from southern Japan revealed they pertained to this species (Tawa et al. 2012).

The known range of this species within the ETP stretches from the southwestern Gulf of California to the coast of Panama (López and Bussing 1964; Rosenblatt et al. 1972; McCosker and Rosenblatt 1995; Robertson and Allen 2015). Its presence has also been reported on several oceanic islands closer to the GMR, such as Cocos Island (Robertson and Allen 2015) and possibly Malpelo (Bessudo 2021; Robertson pers. comm. 2022). However, excluding a perhaps mistaken record by Grove and Lavenberg (1997), which appears to have led to its inclusion in the publications of McCosker and Rosenblatt (2010) and, by extension, Dale et al. (2021), there is no published evidence for the occurrence of the species in the Galápagos Archipelago.

The first photographic record of *S. tigrina* in the Galápagos Islands (Fig. 3C) was by S. Tonge on 11 August 1988, of a dead individual on a beach of Rábida Island (Fig. 1). When alive, the species is known to inhabit rocky and rubble bottoms on reefs (Robertson and Allen 2015), which is indeed where it was encountered by W. Bensted-Smith on 28 March 2021 near Punta Moreno, Isabela Island, at a depth of 15 m (Fig. 3A), whilst the third encounter was in the crevasse of a lava rock wall on Champion Island off the coast of Floreana by N. Tirado on 31 March 2022 (Fig. 3B). The latter two observations were both made during the Charles Darwin Foundation Subtidal Ecological Monitoring Program and are recorded within the datasets. No further sightings of the species have been reported despite extensive monitoring efforts each year.

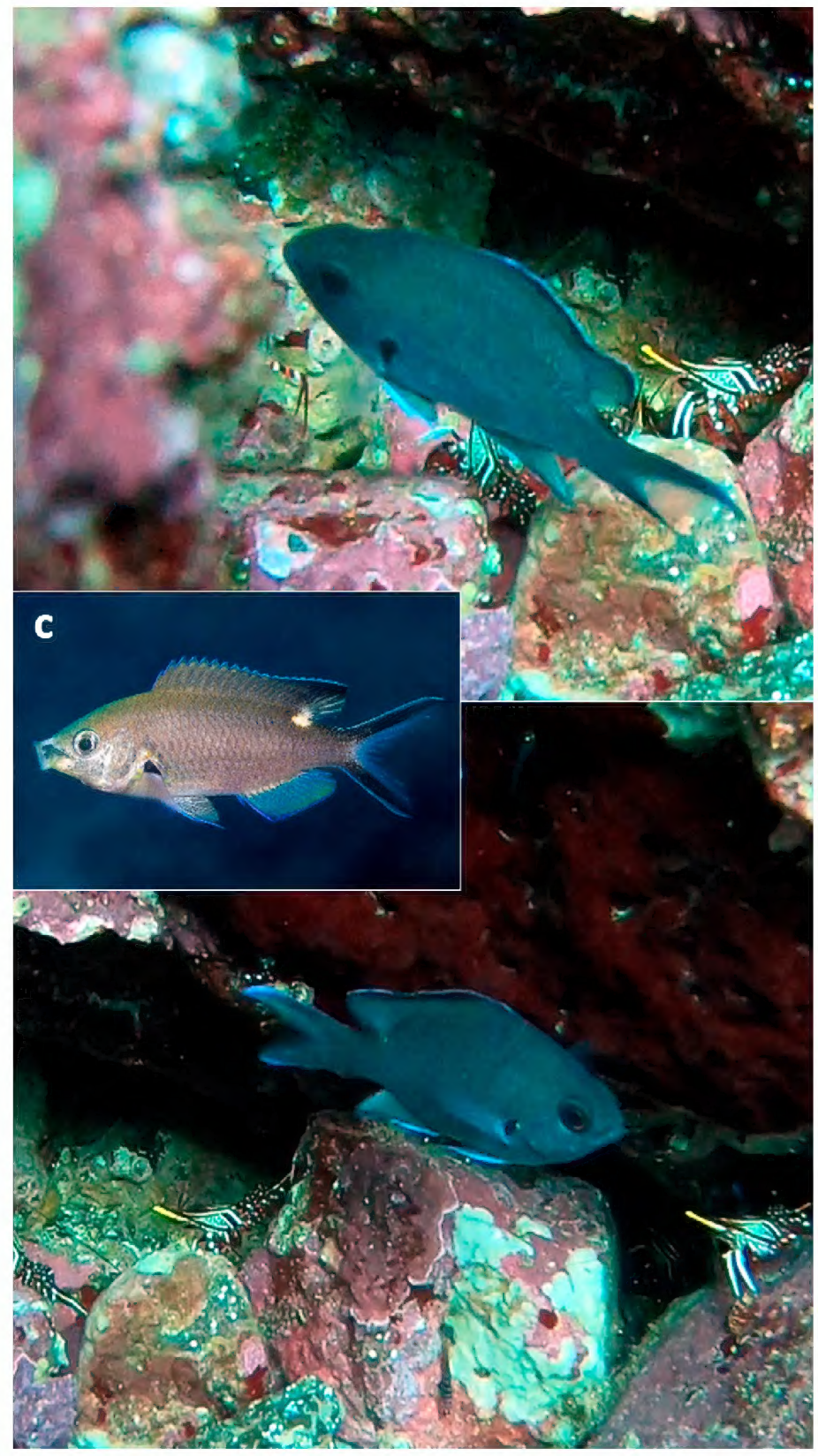

Figure 2. *Azurina* species in the Galápagos. **A, B.** *A. intercrusma*. Side view of juvenile at Punta Moreno, Isabela Island, Galápagos on 7 April 2022 at a depth of 6 m. Screenshots of video by W. Bensted-Smith. **C.** *A. atrilobata*. Side view for comparison; photo taken by Allison Estape.

Methods

The species listed within this paper were all observed during subtidal surveys as part of the Subtidal Ecological Monitoring program which is undertaken annually across the different bioregions of the Galápagos Marine Reserve (Edgar et al. 2004; Kislik et al. 2017) with the aim of examining trends in subtidal communities during the warm season months experienced by the archipelago between diagnostic sites and years. This effort is undertaken by trained researchers of the

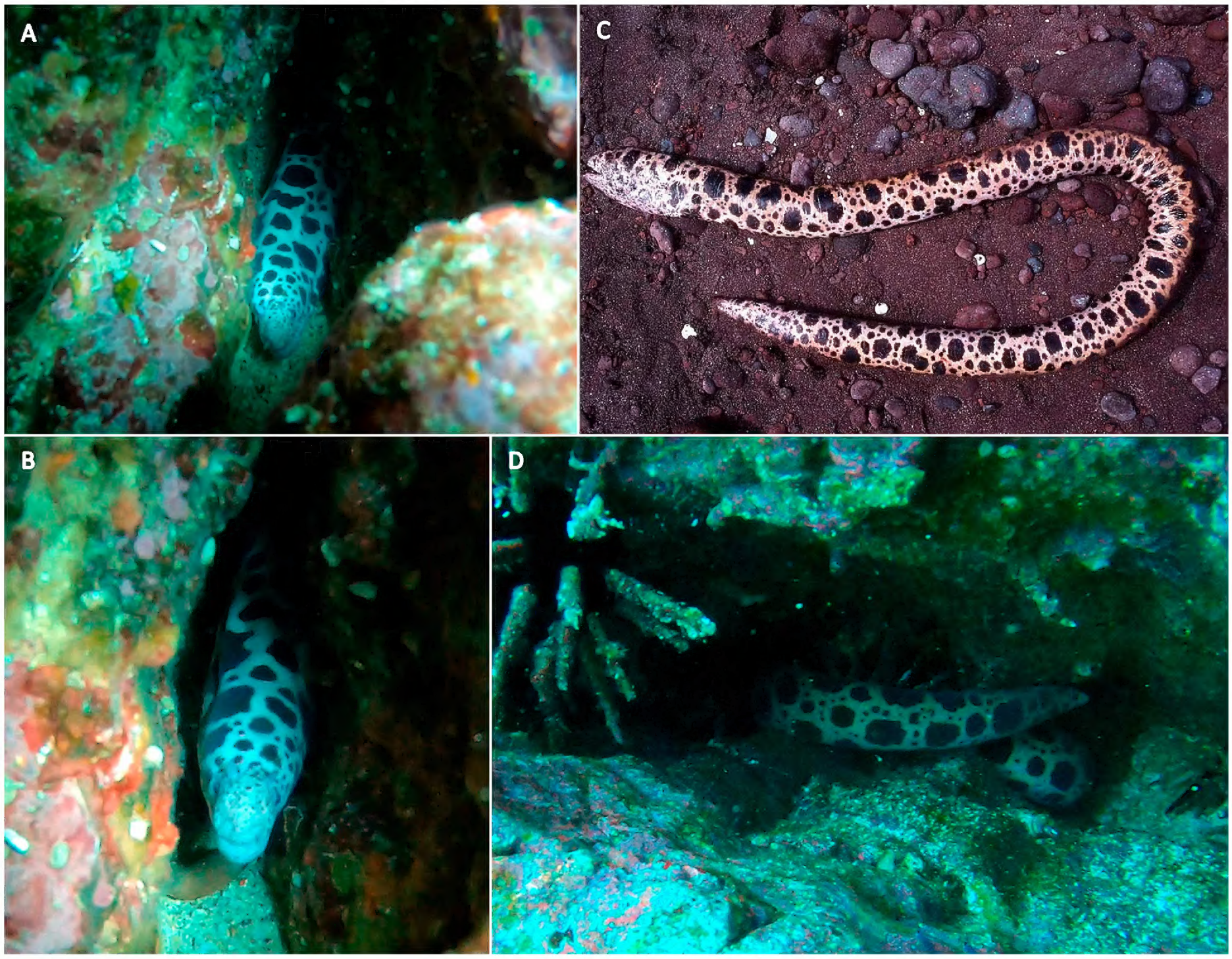

Figure 3. *Scuticaria tigrina*. **A.** Head, frontal and side view. **B.** Head and frontal view. At Punta Moreno of Isabela Island, Galápagos on 28 March 2021, at a depth of 15 m. Screenshots of video by W. Bensted-Smith. **C.** Full-body side view at Rábida Island off Santiago Island, Galápagos on 11 October 1988, onshore, photo by S. Tonge. **D.** Body side view at Champion Island off Floreana Island, Galápagos on 31 March 2022, at a depth of 15 m, photo by N. Tirado.

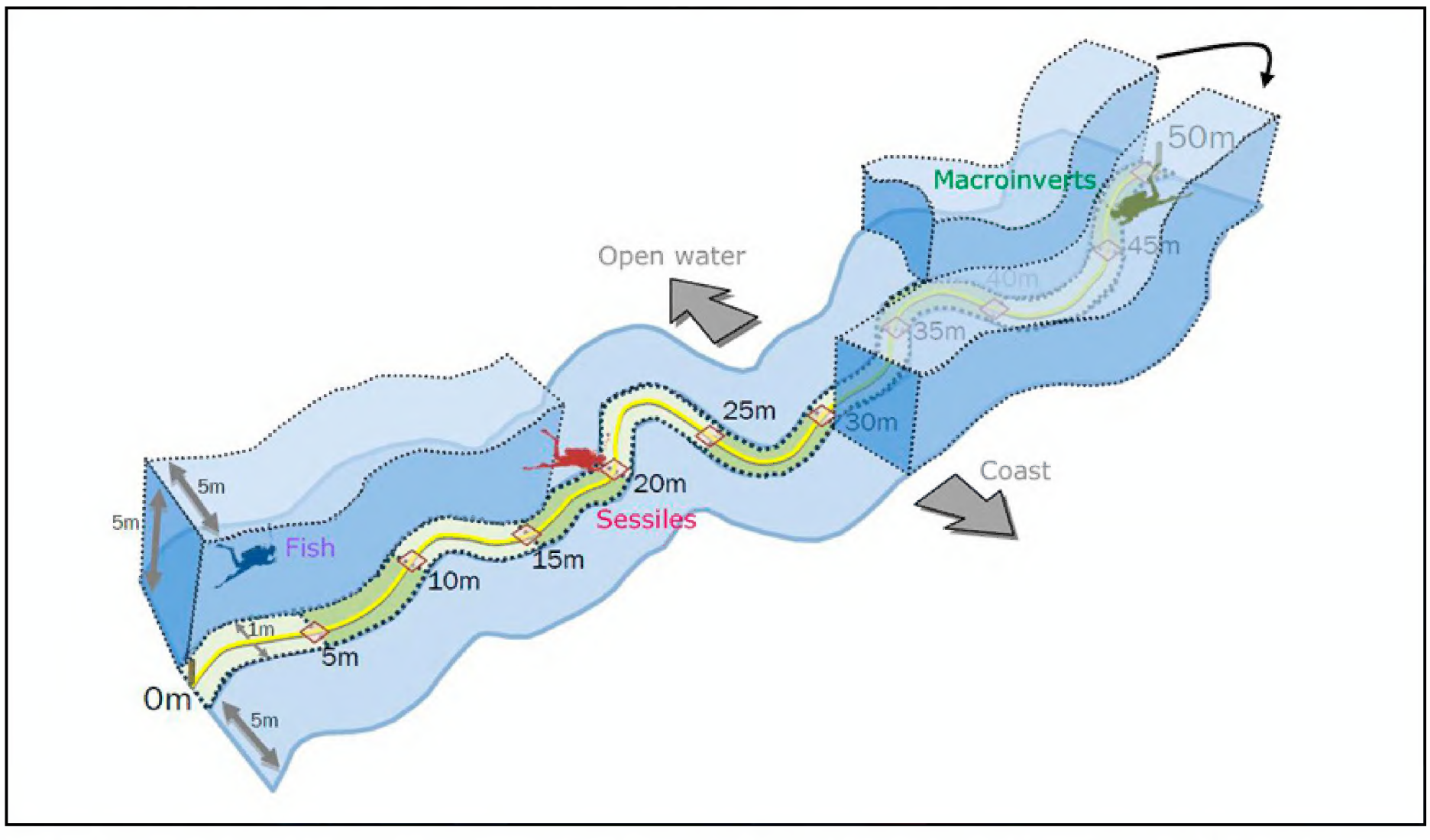

Figure 4. Schematic of a 50 m subtidal transect analogous to the Reef Life Survey methodology with the difference that sessile biota point interception quadrats are scored in-situ (Banks 2014).

Charles Darwin Research Station (CDRS) together with Galápagos National Park Rangers and covers 63 diagnostic coastal sites, across nine islands, at which non-fixed 50 m transects are laid along two standard depth strata (15 m and 6 m) usually parallel to the coastline (Banks 2014). The subtidal monitoring process follows the methods set out by Edgar et al. (2004) and Banks (2014b), with four monitored groups surveyed by three trained divers each performing an authorised non-invasive visual census.

Within the demersal fish and coastal vertebrates group, the diver must complete an along-track visual census which encompasses a 1250 m^3 volume of water on each side of the transect and is repeated for both depths (Fig. 4) (Banks et al. 2016). During the return-pass (coastal side of transect in Fig. 1) of each transect, special focus is given to small and cryptic species which may not have been detected in the first pass (Banks 2014); it was during these return passes when the presence of *Azurina intercrusma* and *Scuticaria tigrina* were observed and recorded.

Results

Azurina intercrusma (Evermann & Radcliffe 1917)

Photographic record. ECUADOR – **Galápagos** • Isabela, Punta Moreno; 00.703°S, 091.331°W; 6 m depth; 07.IV.2022; W. Bensted-Smith obs.; 1 individual photographed.

Identification. *Azurina intercrusma* is a relatively large damselfish with a maximum known length of 290 mm, although individuals of ~150 mm TL are more commonly observed (Prado and Béarez 2004; Robertson and Allen 2015). It can often be confused with the similar-looking *Chromis crusma* (Valenciennes, 1833), which inhabits the same regional coastal waters; however, these two species can be readily differentiated by several morphological differences, including the number of dorsal spines, XIII (rarely XIV) on *C. crusma*, with the rear shorter than the middle, compared to *Azurina intercrusma*'s XII, all equal in length. In addition, *A. intercrusma* has distinctly angular ends of the soft dorsal and anal fins, whereas *C. crusma*'s soft dorsal and anal fins are broadly rounded (Chirichigno Fonseca and Vélez Dieguez 1998) and the former's pectorals are of moderate size, often less than or equal to the length of the head, while the latter's are always longer (Evermann and Radcliffe 1917). The colouration is blue-grey on the upper half, fading to paler grey further down the flanks, whilst the fins are also of a dark-grey shade.

The juvenile stage of this species has a similarly grey-coloured head, body, and fins as the adult. However, the iridescent blue outer edges of the dorsal, pelvic, and anal fins, as well as the upper and lower edges of the caudal fin (Fig. 5A), make it stand out from other species such as *C. crusma* with black edges to the dorsal and anal fins, and a dark tail fin (Fig. 5B). This can cause some confusion since the outer third of *A. intercrusma*'s dorsum is also black. Both juveniles also have a black spot at the base of the pectoral fin (Robertson and Allen 2015). The congener *A. atrilobata* also shows a similar body shape and the black spot at the base of the pectoral fin; this species is commonly found in Galápagos waters as well as throughout the ETP, partially overlapping with the range of *A. intercrusma* (Robertson and Allen 2015; OBIS 2023). Furthermore, *A. atrilobata* is known to occasionally have faint blue edges to its dorsal, anal, and pelvic fins, adding to the similarities between both species. These two species can be differentiated by the presence of an intensely blackish streak on the lobe of each caudal fin of *A. atrilobata* and the prominent white spot just below the end of the base of the soft dorsal fin also present on this species (Fig. 2C), both of which are lacking on both adults and juveniles of *A. intercrusma* (Robertson and Allen 2015).

Scuticaria tigrina (Lesson 1828)

Photographic records. ECUADOR – **Galápagos** • Rábida Island; 00.406°S, 090.716°W; 0 m a.s.l.; 11.VIII.1988; S. Tonge obs.; 1 dead individual photographed • Isabela, Punta Moreno; 00.691°S, 091.318°W; 15 m depth; 28.III.2021; W. Bensted-Smith obs.; 1 individual photographed • Floreana, Champion; 01.236°S, 090.387°W;

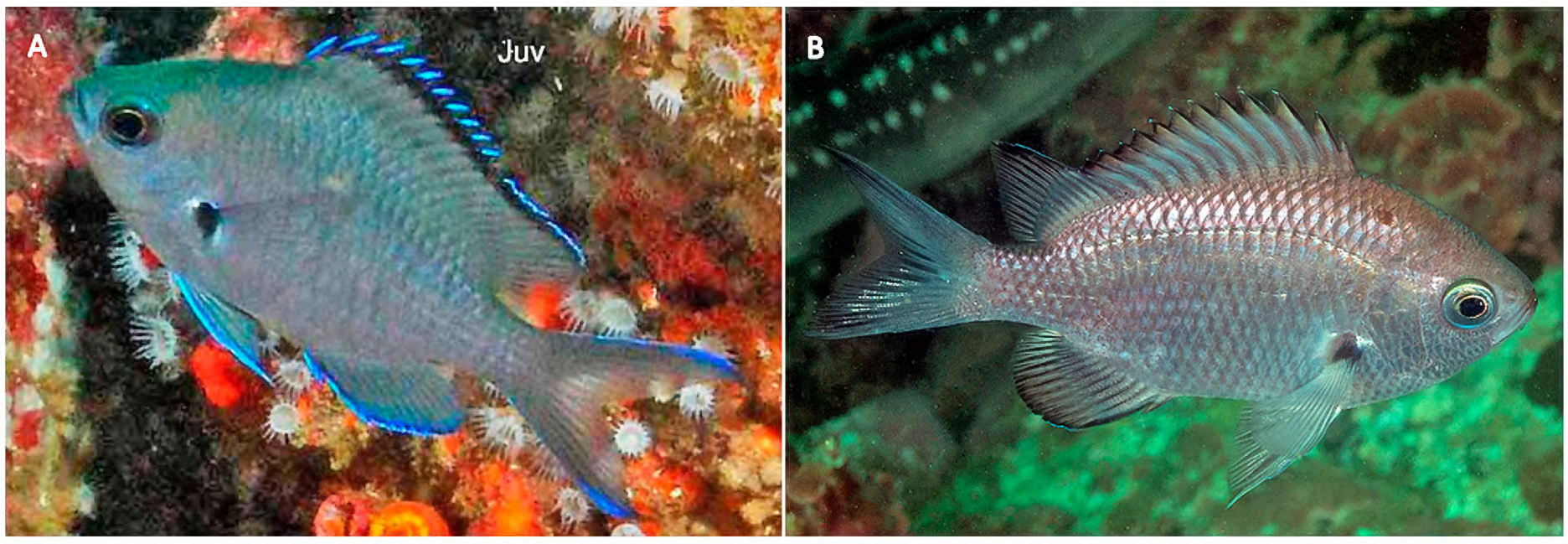

Figure 5. Juveniles, in side view, of *Azurina intercrusma* and *Chromis crusma*. **A.** *A. intercrusma*, photo by Graham Edgar. **B.** *Chromis crusma*, photo by Rick Stuart-Smith.

Figure 6. *Scuticaria tigrina* and *Uropterygius polyspilus*. **A, B.** *S. tigrina*: (**A**) in side view showing spotted pattern on the body, photo by Carol Cox; (**B**) close-up of head features, photo by Allison Estape. **C, D.** *U. polyspilus*: (**C**) side and front view of head and body; (**D**) close-up of head features, photos taken by David Rolla.

15 m depth; 31.III.2022; N. Tirado obs.; 1 individual photographed.

Identification. *Scuticaria tigrina* is known to reach sizes of 140 cm and inhabits coastlines between depths of 5 and 25 m (Allen and Erdmann 2012; Robertson and Allen 2015). It has been confused at times with a similar species, *Uropterygius polyspilus* (Regan, 1909); both species have an elongate, almost cylindrical, snake-like body with similar body colouration and pattern: pale yellowish grey to russet and covered in yellow-edged dark blotches along the body and smaller black spots on the rounded snout and jaws (Fig. 6) (Böhlke and McCosker 1997; Kuiter and Tonozuka 2001; Robertson and Allen 2015). In addition, both species have short fins restricted to the tail tip (Böhlke and Randall 2000), and these similarities have led to these species being confused in at least one case (Gosline 1958). Nevertheless, there are some key differences which readily separate the two species; the position of the anus of *S. tigrina* is the clearest identifier, far behind the mid-body compared to around the mid-body for *U. polyspilus*. Identification underwater can be aided by the shorter snout and jaw equipped with large, swollen and olive-shaped posterior nostril tubes on adults of *U. polyspilus* (Fig. 6D) compared to smaller, straight, and tubular nostrils on *S. tigrina* (Fig. 6B) (Böhlke and McCosker 1997).

Discussion

This publication provides the first photographic evidence of the presence of the Peruvian chromis, *Azurina intercrusma*, in the Galápagos Archipelago, as well as the first confirmed published record of *Scuticaria tigrina*, whose presence in the islands can be traced back to 1988 with the first photo record, albeit of a deceased specimen. All observations of these species in the Galápagos Archipelago have been of lone individuals with substantial geographical distance between them, suggesting it is unlikely that they have yet established breeding populations in the region.

One observation of note is the morphological similarity of juvenile *A. intercrusma* with adult *A. atrilobata*, as well as the close proximity of the two species at the location where they were filmed together. Prior to the onset of the 1982–1983 El Niño, the endemic pomacentrid *A. eupalama* was most often observed in heterotypic, plankton-feeding aggregations with *A. atrilobata* (Grove and Lavenberg 1997), and Robertson et al. (2021) suggested that juveniles of *Lutjanus inermis* (Peters, 1869) in the Galápagos could possibly remain undetected in schools of *A. atrilobata* due to their semblance and only become distinguishable as adults. It is therefore possible that similar behaviours are being adopted by solitary or small groups of *A. intercrusma*

juveniles which arrive at the islands. Both species are known to have native ranges which overlap along the coastlines of southern Ecuador and northern Peru (Robertson and Allen 2015), which could suggest it is a common occurrence, but there have been no studies regarding this activity. Regardless of whether this activity is common, it is apparent that morphologically similar fish will occasionally aggregate (Parrish 1989; Croft et al. 2003; Tessier et al. 2005), which may be the case if *A. intercrusma* juveniles arrive at the Galápagos. The discovery of *A. intercrusma*, alongside the recent confirmation of the presence of *L. inermis* in the archipelago suggests more care should be taken when recording schools of Chrominae during monitoring efforts; this will help identify possible new or rare arrivals from other regions of the Pacific Ocean. The site is scheduled to be visited again for monitoring purposes in 2023, at which time the divers will look closely for this species, making sure to consider its possible aggregation with *A. intercrusma*.

The known native range of *A. intercrusma* only extends as far north as the southern coast of Ecuador, over 1,100 km from the location the juvenile was found, in an area under the influence of the Humboldt Current, Chile Coastal Current, Peru Coastal Current, and the counter currents of the latter two (Kessler 2006; Thatje et al. 2008; Chaigneau et al. 2013). During La Niña years a cold tongue of upwelled waters from the Antarctic extends offshore from northern Peru to the Galápagos Islands, advected offshore by Ekman currents due to the enhanced trade winds (Fiedler and Talley 2006; Grados et al. 2018). Increased offshore transport of larvae is thought to occur with the stronger upwelling conditions, although the effect on strong swimming larvae is diminished (Gaymer et al. 2010). The occurrence of this phenomena could create the conditions necessary for the westward transport of *A. intercrusma* larva; members of the same genus are known to have a planktonic larval duration of over 30 days (Wellington and Victor 1989; Victor and Wellington 2000) between the continental and insular coastlines. The observation was made during a La Niña event which has been ongoing since November 2021 and is the third such event in a row (Bureau of Meteorology 2022), which suggests there could be a link between the two. The fish was found at Punta Moreno along the western shore of Isabela Island (Fig. 1B), on the edge of the Canal Bolivar/Elizabeth bioregion (Edgar et al. 2004), an area known to be 5–6 °C cooler than nearby islands and highly productive due to the upwelling of the Equatorial Undercurrent (EUC) bringing colder and nutrient rich waters from the deep (Houvenaghel 1978; Eden and Timmermann 2004; McCosker and Rosenblatt 2010; Ruiz and Wolff 2011; Wolff et al. 2012).

Originating from the Indo-Pacific, an area known as the heat engine of the world (De Deckker 2016), *Scuticaria tigrina*'s "typical" habitat is much warmer than that of *A. intercrusma*; however, both species were found at the same location (albeit a year apart) known for its colder waters. This can be explained by the observation occurring during the warm season of the Galápagos Archipelago in which the EUC upwelling weakens, along with the Humboldt Current, and the warmer Panama Current is dominant, raising the water temperature, even in the cold west, by several degrees Celsius (Houvenaghel 1984; Kessler 2006; Schaeffer et al. 2008; Glynn et al. 2017). Strong El Niño events, such as in 1982/83 or 1997/8, are thought to be possible vectors for the arrival of Indo-Pacific species at fringe islands of the ETP like the Galápagos, but these are often only temporary vagrants and it likely does not represent a major source of transpacific migration (Robertson et al. 2004). Another possible advection route is from the continental coastline and islands of Costa Rica, Panama, and Colombia, where this species is known to be present, with increased flow during the warmer season. As mentioned before, the Galápagos is host to nearly all species of muraenids recorded from the Indo-Pacific, be they vagrants or resident populations (McCosker and Rosenblatt 2010). The potential of muraenid arrival in the Galápagos could be aided by the greater leptocephali larvae swimming potential and larval life history of this family, which has enabled them to be highly dispersive whilst maintaining minimal genetic differentiation between populations (Grove and Lavenberg 1997; Reece et al. 2011). The sporadic observations of *S. tigrina* as well as its absence in the major fish collections carried out in the Galápagos suggest that this species is likely only a vagrant there.

The record of this species in McCosker and Rosenblatt's (2010) *The Fishes of the Galápagos Archipelago: An Update* is unclear. *Scuticaria tigrina* is mentioned in only two of the references cited (Rosenblatt et al. 1972; Grove and Lavenberg 1997), and it is unlikely the species was found during the submersible expeditions in the recent years prior to the publication, since there is no reference to *S. tigrina* being found during these as well as the study area being outside of the species' depth range (Robertson and Allen 2015). In Grove and Lavenberg (1997), *S. tigrina* (as *S. tigrinus*) is among the species which they mention has been captured in the Galápagos archipelago, stating that "only one of the muraenid eels of Indo-Pacific origin has not: *Enchelynassa canina*", which remains undetected here (GBIF 2023; OBIS 2023). Nevertheless, no mention is made of when or where it had been collected, and there appear to be no records from museum collections confirming its presence in the islands (FishNet 2 2023; GBIF 2023; OBIS 2023).

The first known photographic record of *S. tigrina* in the Galápagos Islands is from 1988 and would likely not have been known to science or species records without the help of citizen science sites such as iNaturalist (Aristeidou et al. 2021). The fact it was only uploaded in 2018 shows the importance of sharing private photo collections through these sites to help identify new species and uncommon vagrants.

Both species mentioned are also included within the recently published list of Galápagos fishes (Grove et al. 2022). *Scuticaria tigrina* is listed therein as a vagrant based upon the iNaturalist observation by S. Tonge and personal communications from us, whilst *A. intercrusma*'s inclusion as a vagrant is based solely upon the record contained herein. Despite these records, this publication provides the evidence of first live sightings of both these species in the Galápagos Islands and is therefore an important addition to the scientific literature on the fishes of the Galápagos.

Acknowledgements

We thank Ross Robertson and Benjamin Victor for their help regarding both the identification of these species as well as the motivation and helpful information they have given during the writing of this paper. We would like to also thank Rashid Cruz for his help in editing the photos of the species included in this publication. Furthermore, we thank Emily McFarling and Johny Mazón for their help creating the map, and Nathalia Tirado of the Charles Darwin Research Station for spotting, photographing, and giving us permission to use the image of *Scuticaria tigrina* at Champion Island (Fig. 3D).

Last but certainly not least, we thank the photographers who allowed us to use their high-quality images within this publication: Simon Tonge for providing his photo of *S. tigrina*; Allison Estape for her photos of *Azurina atrilobata* and *S. tigrina*; Graham Edgar for his photo of a juvenile *A. intercrusma*; Rick Stuart-Smith for his photo of a juvenile *Chromis crusma*; Carol Cox for her photo of *S. tigrina*; and David Rolla for his photos of *Uropterygius polyspilus*.

All authors would like to thank the Galapagos National Park for granting us authorization to carry out this investigation (research permit number: PC-07–22) and the Charles Darwin Foundation for providing us the opportunity to carry out our research. This publication is contribution number 2546 of the Charles Darwin Foundation for the Galapagos Islands.

Author Contributions

Conceptualisation: WBS. Data curation: WBS. Formal analysis: WBS. Funding acquisition: IK. Investigation: WBS, IK. Methodology: SB. Resources: IK. Supervision: IK, JG, SB. Visualisation: WBS. Project administration: IK. Software: WBS. Validation: JG. Writing – original draft: WBS. Writing – review and editing: WBS, IK, JG, SB.

References

Allen GR, Erdmann M (2012) Reef fishes of the east indies, volume I: sharks, rays, and bony fishes: eels to groupers). University of Hawai'i Press, Perth, Australia.

Aristeidou M, Herodotou C, Ballard HL, Young AN, Miller AE, Higgins L, Johnson R F (2021) Exploring the participation of young citizen scientists in scientific research: the case of iNaturalist. PloS ONE 16(1): e0245682. https://doi.org/10.1371/journal.pone.0245682

Banks S (2014) Ecological trends in Galápagos Marine Reserve subtidal reef communities: a report for the Conservation International Americas Field Division Marine Program. Conservacion Internacional Ecuador, Quito, Ecuador, 74 pp.

Banks S, Acuña D, Brand, M, Calderón R, Delgado J, Edgar G, Garske-Garcia L, Keith I, Kuhn A, Pépolas R, Ruiz D, Suárez J, Tirado N, Vera M, Vinueza L, Wakefield E (2016) Manual de monitoreo submareal ecológico para la reserva marina de Galápagos. Banks S (Ed). Quito, Ecuador, 138 pp.

Bessudo S (2021) Inventario de peces del SFF isla Malpelo, Proyecto Colombia Bio. Version 2.5. Fundación Malpelo y Otros Ecosistemas Marinos, Colombia. https://doi.org/10.15472/yde8tf

Böhlke EB, McCosker JE (1997) Review of the moray eel genus *Scuticaria* and included species (Pisces: Anguilliformes: Muraenidae: Uropterygiinae). Proceedings of the Academy of Natural Sciences of Philadelphia 148: 171–176.

Böhlke EB, Randall JE (2000) A review of the moray eels (Angulliformes: Muraenidae) of the Hawaiian Islands, with descriptions of two new species. Proceedings of the Academy of Natural Sciences of Philadelphia 150: 203–278.

Bureau of Meteorology (2022) ENSO Outlook, Australian Government. http://www.bom.gov.au/climate/enso/outlook/#tabs=ENSO-Outlook-history. Accessed on 2022-8-22.

Bustamante RH, Collins KJ, Bensted-Smith R (2000) Biodiversity conservation in the Galápagos marine reserve. Bulletin de l'Institut Royal des Sciences Naturelles de Belgique 70: 31–38.

Carlton JT, Keith I, Ruiz GM (2019) Assessing marine bioinvasions in the Galápagos Islands: implications for conservation biology and marine protected areas. Aquatic Invasions 14: 1–20. https://doi.org/10.3391/ai.2019.14.1.01

Chaigneau A, Dominguez N, Eldin G, Vasquez L, Flores R, Grados C, Echevin V (2013) Near-coastal circulation in the Northern Humboldt Current System from shipboard ADCP data. Journal of Geophysical Research: Oceans 118: 5251–5266. https://doi.org/10.1002/jgrc.20328

Chirichigno Fonseca N, Vélez Dieguez J (1998) Clave para identificar los peces marinos del Peru (Segunda edición, revisada y actualizada). Instituto del Mar del Perú, Callao, Peru, 469 pp.

Croft DP, Arrowsmith BJ, Bielby J, Skinner K, White E, Couzin ID, Magurran AE, Ramnarine I, Krause J (2003) Mechanisms underlying shoal composition in the Trinidadian guppy, *Poecilia reticulata*. Oikos 100(3): 429–438. https://doi.org/10.1034/j.1600-0706.2003.12023.x

Dale KE, Ramírez-Valdez A, McCosker JE, Love MS (2021) Revising geographic distributions of eastern Pacific moray eels. Bulletin of Marine Science 97(2): 305–325. https://doi.org/10.5343/bms.2020.0060

De Deckker P (2016) The Indo-Pacific Warm Pool: critical to world oceanography and world climate. Geoscience

Letters 3(20): 1–12. https://doi.org/10.1186/s40562-016-0054-3

Eden C, Timmermann A (2004) The influence of the Galápagos Islands on tropical temperatures, currents and the generation of tropical instability waves. Geophysical Research Letters 31(15): e2004GL020060. https://doi.org/10.1029/2004GL020060

Edgar GJ, Banks SA, Brandt M, Bustamante RH, Chiriboga A, Earle SA, Garske LE, Glynn PW, Grove JS, Henderson S, Hickman CP, Miller KA, Rivera F, Wellington GM (2010) El Niño, grazers and fisheries interact to greatly elevate extinction risk for Galápagos marine species. Global Change Biology 16(10): 2876–2890. https://doi.org/10.1111/J.1365-2486.2009.02117.X

Edgar GJ, Banks S, Fariña JM, Calvopiña M, Martínez C (2004) Regional biogeography of shallow reef fish and macro-invertebrate communities in the Galápagos archipelago. Journal of Biogeography 31(7): 1107–1124. https://doi.org/10.1111/j.1365-2699.2004.01055.x

Evermann BW, Radcliffe L (1917) The fishes of the west coast of Peru and the Titicaca Basin. Bulletin of the United States National Museum Bulletin 9: 1–166. https://doi.org/10.5479/si.03629236.95.i

Fiedler PC, Talley LD (2006) Hydrography of the eastern tropical Pacific: a review. Progress in Oceanography 69(2–4): 143–180. https://doi.org/10.1016/j.pocean.2006.03.008

FishNet 2 (2023) http://www.fishnet2.net/. Accessed on: 2023-3-23.

Gaymer CF, Palma AT, Alonso Vega JM, Monaco CJ, Henríquez LA (2010) Effects of La Niña on recruitment and abundance of juveniles and adults of benthic community-structuring species in northern Chile. Marine and Freshwater Research 61: 1185–1196. https://doi.org/10.1071/MF09268

GBIF (Global Biodiversity Information Facility) (2023) https://www.gbif.org/. Accessed on: 2023-3-23.

Glynn P, Alvarado J, Banks S, Cortés J, Feingold J, Jiménez C, Maragos J, Martínez P, Maté J, Moanga D, Navarrete S, Reyes-Bonilla H, Riegl B, Rivera F, Vargas-Ángel B, Wieters E, Zapata F (2017) Eastern Pacific coral reef provinces, coral community structure and composition: an overview. In: Glynn P, Manzello D, Enochs I (Eds.) Coral reefs of the Eastern Tropical Pacific. Coral reefs of the world, volume 8. Springer, Dordrecht, the Netherlands, 107–176.

Gosline WA (1958) Central Pacific eels of the genus *Uropterygius*, with descriptions of two new species. Pacific Science 12(3): 221–228.

Grados C, Chaigneau A, Echevin V, Dominguez N (2018) Upper ocean hydrology of the Northern Humboldt Current System at seasonal, interannual and interdecadal scales. Progress in Oceanography 165: 123–144. https://doi.org/10.1016/j.pocean.2018.05.005

Grove JS, Lavenberg RJ (1997) The fishes of the Galápagos Islands. Stanford University Press, Stanford, USA, 863 pp.

Grove JS, Long DJ, Robertson DR, Victor BC (2022) List of fishes of the Galápagos Archipelago, Ecuador. Journal of the Ocean Science Foundation 39: 14–22. https://doi.org/10.5281/zenodo.7065587

Heller E, Snodgrass RE (1903) Papers from the Hopkins Stanford Galápagos Expedition, 1898–1899. XV. New fishes. Proceedings of the Washington Academy of Sciences 5: 189–229

Houvenaghel GT (1978) Oceanographic conditions in the Galápagos Archipelago and their relationships with life on the islands. In: Boje R, Tomczak M (Eds.) Upwelling ecosystems. Springer, Berlin, Germany, 181–200.

Houvenaghel, GT (1984) Oceanographic setting of the Galápagos Islands. In: Perry R (Ed.) Key environments: Galápagos. Pergamon Press, Oxford, UK, 43–54.

iNaturalist (2023) https://www.inaturalist.org/observations. Accessed on: 2023-3-23.

Jordan DS, Evermann BW (1896) The fishes of North and Middle America: a descriptive catalogue of the species of fish-like vertebrates found in the waters of North America, north of the Isthmus of Panama Part I. US Government Printing Office, Washington DC, USA.

Keith I, Dawson TP, Collins KJ, Campbell ML, Keith I, Dawson TP, Collins KJ, Campbell ML (2016) Marine invasive species: establishing pathways, their presence and potential threats in the Galápagos Marine Reserve. Pacific Conservation Biology 22(4): 377–385. https://doi.org/10.1071/pc15020

Kessler WS (2006) The circulation of the eastern tropical Pacific: a review. Progress in Oceanography 69: 181–217. https://doi.org/10.1016/j.pocean.2006.03.009

Kislik E, Saltos GM, Torres G, Borbor-Córdova M (2017) Biological hotspots in the Galápagos Islands: exploring seasonal trends of ocean climate drivers to monitor algal blooms. International Journal of Science, Engineering and Technology 11(12): 824–834. https://doi.org/10.5281/zenodo.1314831

Kuiter RH, Tonozuka T (2001) Pictorial guide to Indonesian reef fishes. Part 1. Eels– snappers, Muraenidae–Lutjanidae. Zoonetics, Seaford, Australia, 302 pp.

Loh KH, Chen IS, Randall JE, Chen HM (2008) A review and molecular phylogeny of the moray eel subfamily Uropterygiinae (Anguilliformes: Muraenidae) from Taiwan, with description of a new species. The Raffles Bulletin of Zoology 19: 135–150.

López M, Bussing W (1964) University of Costa Rica (UCR) Fish database. Museum of Zoology, Biology Department, University of Costa Rica, San Jose, Costa Rica.

Martínez Panizo PC, Rivera F, Peñaherrera J, Rivera F, Jácome I, Chipe V, Bolaños S, Castro I, León E, Chocho V (2022) Monitoreo de biodiversidad del Intermareal Rocoso Reservas Marinas: El Pelado, Bajo Copé y Cantagallo – Machalilla. Ministerio del Ambiente, Agua y Transición Ecológico, Quito, Ecuador. https://doi.org/10.15468/bum4zw

McCosker JE, Rosenblatt RH (1995) Muraenidae. Morenas. In: Fischer W, Krupp F, Schneider W, Sommer C, Carpenter KE, Niem VH (Eds) Guía FAO para la identificación de especies para los fines de la pesca. Pacífico centro-oriental, volumen III. Vertebrados—parte 2. Food and Agriculture Organization of the United Nations, Rome, Italy, 1303–1315.

McCosker JE, Rosenblatt RH (2010) The fishes of the Galápagos Archipelago: an update. Proceedings of the

California Academy of Sciences 61(2): 167–195.

Ministerio del Ambiente (2020) Red de áreas marinas y costeras protegidas del Ecuador Subsecretaría de Gestión Marino Costera. https://docplayer.es/177998006-Red-de-areas-marinas-y-costeras-protegidas-del-ecuador-subsecretaria-de-gestion-marino-costera.html. Accesed on 2023-2-10

OBIS (Ocean Biogeographic Information System) (2023) https://obis.org/. Accessed on: 2023-3-23.

Orton GL (1953) The systematics of vertebrate larvae. Systematic Biology 2(2): 63–75. https://doi.org/10.2307/sysbio/2.2.63

Parrish JK (1989) Layering with depth in a heterospecific fish aggregation. Environmental Biology of Fishes 26: 79–85.

Prado PJ, Béarez P (2004) Peces marinos del Ecuador continental. Tomo 2: guía de especies / Marine fishes of continental Ecuador. Volume 2: species guide. SIMBIOE/NAZCA/IFEA, Quito, Ecuador, 124 pp.

Reece JS, Bowen BW, Smith DG, Larson A (2011) Comparative phylogeography of four Indo-Pacific moray eel species (Muraenidae) reveals comparable ocean-wide genetic connectivity despite five-fold differences in available adult habitat. Marine Ecology Progress Series 437: 269–277.

Robertson DR, Allen GR (2015) Shorefishes of the Tropical Eastern Pacific: online information system, version 2.0. Smithsonian Tropical Research Institute, Balboa, Panamá. https://biogeodb.stri.si.edu/sftep/en/pages. Accesed on 2023-2-10

Robertson DR, Cox CD, Cox RL (2021) *Lutjanus inermis* (Peters, 1869), Golden Snapper, range extension to the Galápagos Islands. Check List 17(6): 1633–1637. https://doi.org/10.15560/17.6.1633

Robertson DR, Grove JS, McCosker JE (2004) Tropical Transpacific shore fishes. Pacific Science 58(4): 507–565. https://doi.org/10.1353/psc.2004.0041

Rosenblatt RH, McCosker JE, Rubinoff I (1972) Indo-West Pacific fishes from the Gulf of Chiriqui, Panama. Los Angeles County Museum of Natural History Contributions in Science 234: 1–18. https://doi.org/10.5962/p.241218

Ruiz DJ, Wolff M (2011) The Bolivar Channel Ecosystem of the Galápagos Marine Reserve: energy flow structure and role of keystone groups. Journal of Sea Research 66: 123–134. https://doi.org/10.1016/j.seares.2011.05.006

Russell BC, Craig MT (2013) *Anampses viridis* Valenciennes 1840 (Pisces: Labridae)—a case of taxonomic confusion and mistaken extinction. Zootaxa 3722(1): 83–91. https://doi.org/10.11646/zootaxa.3722.1.7

Schaeffer BA, Morrison JM, Kamykowski D, Feldman GC, Xie L, Liu Y, Sweet W, McCulloch A, Banks S (2008) Phytoplankton biomass distribution and identification of productive habitats within the Galápagos Marine Reserve by MODIS, a surface acquisition system, and in-situ measurements. Remote Sensing of Environment 112(6): 3044–3054. https://doi.org/10.1016/j.rse.2008.03.005

Strathmann RR (1993) Hypotheses on the origins of marine larvae. Annual Review of Ecology and Systematics 24: 89–117.

Tang KL, Stiassny MLJ, Mayden RL, DeSalle R (2021) Systematics of damselfishes. Ichthyology & Herpetology 109(1): 258–318. https://doi.org/10.1643/I2020105

Tawa A, Kobayakawa M, Yoshimura T, Mochioka N (2012) Identification of leptocephalus larvae of the tiger moray *Scuticaria tigrina* (Anguilliformes; Muraenidae) based on morphometric and genetic evidence. Ichthyological Research 59: 378–383. https://doi.org/10.1007/s10228-012-0292-0

Tessier E, Chabanet P, Pothin K, Soria M, Lasserre G (2005) Visual censuses of tropical fish aggregations on artificial reefs: slate versus video recording techniques. Journal of Experimental Biology and Ecology 315(1): 17–30. https://doi.org/10.1016/j.jembe.2004.08.027

Thatje S, Heilmayer O, Laudien J (2008) Climate variability and El Niño Southern Oscillation: implications for natural coastal resources and management. Helgoland Marine Research 62(1): 5–14. https://doi.org/10.1007/s10152-008-0104-0

Victor BC, Wellington GM (2000) Endemism and the pelagic larval duration of reef fishes in the eastern Pacific Ocean. Marine Ecology Progress Series 205: 241–248.

Wellington GM, Victor BC (1989) Planktonic larval duration of one hundred species of Pacific and Atlantic damselfishes (Pomacentridae). Marine Biology 101: 557–567.

Wolff M, Ruiz DJ, Taylor M (2012) El Niño induced changes to the Bolivar Channel ecosystem (Galápagos): comparing model simulations with historical biomass time series. Marine Ecology Progress Series 448: 7–22. https://doi.org/10.3354/meps09542